J. Raptor Res. 32(1):64–73

STATUS AND CONSERVATION OF RAPTORS IN AUSTRALIA'S TROPICS

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ABSTRACT.—All of Australia's 34 raptors are found in the tropics. No full species and only one subspecies, an island endemic owl, are extinct. All of Australia's three threatened, diurnal species are endemic to the continent. One, the Vulnerable Red Goshawk (*Erythrotriochis radiatus*), is endemic to Australia's tropical forests and is under threat from loss of habitat, persecution, and egg collecting. Conservation efforts include legal protection, education, and keeping nest sites secret. A second species, the rare Square-tailed Kite (*Lophoictinia isura*) is widely distributed and, except for clearing of woodland, threats are not obvious. Many raptors from arid areas, including the endemic Grey Falcon (*Falco hypoleucos*), "winter" in tropical woodlands. For adequate conservation, critical habitats of the Grey Falcon must be identified. Grey Falcons should be helped in the long term by the anticipated reduction of rabbits in arid Australia by rabbit calicivirus disease, but widespread clearing of tropical woodlands for agriculture continues as does local, heavy use of pesticides. Although no species of owls are threatened, five subspecies are; two are subspecies of the endemic Rufous Owl (*Ninox rufa,* one rare and one insufficiently known) and two are subspecies of the Masked Owl (*Tyto novaehollandiae,* both insufficiently known). Threats include loss of critical habitat to fire and agriculture. On Christmas Island, the small populations of endemic subspecies of the Brown Goshawk (*Accipiter fasciatus*) and Moluccan Hawk-owl (*N. squamipila*) are Vulnerable and threatened by loss of habitat to urbanization and formerly mining. Besides legal protection, conservation efforts have included education and habitat preservation. The tropical Eastern Grass-owl (*T. longimembris*) is secure although some populations are under pressure from agriculture (including rodenticides) and urbanization. Coastal, tropical raptors appear secure even though permanent reductions in some populations have been caused by agriculture, urbanization, and coastal developments such as aquaculture and marinas.

KEY WORDS: *tropical raptors; Australia; conservation; status.*

Estado y conservación de las aves rapaces en los trópicos de Australia

RESUMEN.—Todas las 34 especies de aves rapaces de Australia se encuentran en los trópicos. Una de las tres especies amenazadas de Australia, *Erythrotriorchis radiatus* es endémico a los bosques tropicales de Australia y está amenazada por la pérdida de habitat, persecución, y saqueo de huevos. Los esfuerzos de conservación han incluido su protección legal, educación, y protección de nidos. Una segunda especie *Lophoictinia isura* está ampliamente distribuida, excepto por la deforestación, las demas amenazas no son obvias. Varias aves rapaces de regiones áridas incluyendo al endémico *Falco hypoleucos* emigran hacia los bosques tropicales. Desde el punto de vista de la conservación, los habitats criticos de *F. hypoleucos* deben de ser identificados debido a que la deforestación para la agricultura continúa al igual que el uso intensivo de pesticidas. Aunque ningún buho ha sido identificado como amenazado, en Australia, dos raras y poco estudiadas subespecies del endémico *Ninox rufa* y dos subespecies de *Tyto novaehollandiae* están amenazadas en las áreas tropicales. Las amenazas incluyen la pérdida de habitats críticos debido al fuego y a la agricultura. En la Isla Christmas, las reducidas poblaciones de *Accipiter fasciatus* y de *N. squamipila* están amenazadas debido a la pérdida de habitat por actividades mineras y el desarrollo urbanístico. Aparte de la protección legal, los esfuerzos de conservación han incluido educación y protección del habitat. Aunque aparentemente estables algunas poblaciones de *T. longimembris* están bajo presión debido a la agricultura (incluyendo el uso de rodenticidas) y el desarrollo urbano. Aunque las poblaciones de aves rapaces costeras están estables, estas han tenido continuadas reducciones causadas por la agricultura, la urbanización, y por desarrollos costeros tales como proyectos de acuacultura y marinas.

[Traducción de César Márquez]

BACKGROUND

Australia is a continent with an area totaling about 7.7 million km^2. It includes a few small islands, one of which is Christmas Island in the Indian Ocean, approximately 1400 km northwest of Australia near the Indonesian island of Java. Australia is the driest continent and less than 15% is covered by tropical forests located on the north and northeastern coasts. Although people have slowly modified these forests using fire over at least 60 000 yr, it has only been in the last 200 yr since Europeans arrived that this change has accelerated. While the size of the continent has sheltered most raptors from threats to tropical forests, small islands have not escaped these effects. The wet, tropical forests of Australia show distinct seasonality but have long-term ecological stability. The occurrence of irregular, severe inland droughts make the continent's biogeography unique (Nix 1972, Flannery 1994). This instability has resulted in many arid and semiarid birds, raptors included, becoming migrants during drought periods with many showing both inland-coastal and south-north movements (Baker-Gabb and Fitzherbert 1989). These local movements may be small in relation to the size of the continent but they are still large in absolute terms and their apparent dispersive rather than routed nature makes their study difficult.

Another unusual movement is the irruptive tendency of a few raptor species. This type of movement usually follows heavy rains marked by increases in rodent numbers, and rapid breeding in populations of Letter-winged Kites (*Elanus scriptus*) and Black Kites (*Milvus migrans*) which then disperse when dry conditions return and rodent numbers crash (Hollands 1977, Lavery and Johnson 1993).

This paper examines raptors in wet tropics (a strongly seasonal environment) and dry tropics (an environment stable in the short to medium term but unstable in the longer term). It is important to make this distinction because tropical raptors may be largely dependent on a system with long-term stability and they may be slow to adapt to environmental changes.

The Australian wet tropics contain both open and closed forests, including rainforest on the continent's northeast coast. Mainly coastal, these forests extend from nearly half-way down the east coast and all the way to the northwest corner of Australia. Tropical areas also spread inland along permanent rivers and wetlands and include some areas of highlands such as the Atherton tablelands. Adjacent islands off these areas including Christmas Island are also wet and support rainforests. The dry tropics are comprised of mainly savanna woodlands and a variety of permanent and temporary waterways and wetlands. They are located south of the wet tropics but north of a line extending across the continent from the mid-east to the mid-upper west coast from about Brisbane to about Broome (Fig. 1).

Raptors are very mobile birds and most species are able to utilize a variety of habitats. Therefore, I was cautious when assigning species to habitats and used broad definitions.

USE OF AUSTRALIA'S TROPICS BY RAPTORS

Presence and Core Range. All 34 species of Australian raptors are found in the tropics. Of Australia's 10 endemic raptor species, only two, the monotypic Red Goshawk (*Erythrotriorchis radiatus*) and Lesser Sooty-owl (*Tyto multipunctata*), are endemic to the tropics as are four and eight subspecies of Falconiformes and Strigiformes, respectively. One other monotypic species, the Square-tailed Kite (*Lophoictinia isura*), six subspecies of Falconiformes, and six of Strigiformes have large portions of their ranges in the tropics (Blakers et al. 1984, Debus and Czechura 1988b, Marchant and Higgins 1993). Australia is relatively close to Melanesia and some raptors interchange between the two including Swamp Harriers (*Circus approximans*), Australian Hobbies (*Falco longipennis*), and Nankeen Kestrels (*F. cenchroides*). Numbers of raptors that interchange are not known but neither location is known to be a major wintering area for interchanging species (Baker-Gabb and Fitzherbert 1989).

Wet vs. Dry Tropics. More species of Strigiformes rely on the wet tropics than do Falconiformes. Seven species of Strigiformes are endemic while only three species of Falconiformes are exclusively found in the wet tropics. All told, 10 of Australia's 19 species and subspecies of Strigiformes but only 10 of 28 species and subspecies of Falconiformes are either endemic to or a large segment of their core ranges lies within the wet tropics. Conversely, the dry tropics are more important to the majority of Australia's tropical Falconiformes. Six species are endemic to the dry tropics while this area has no endemic owls.

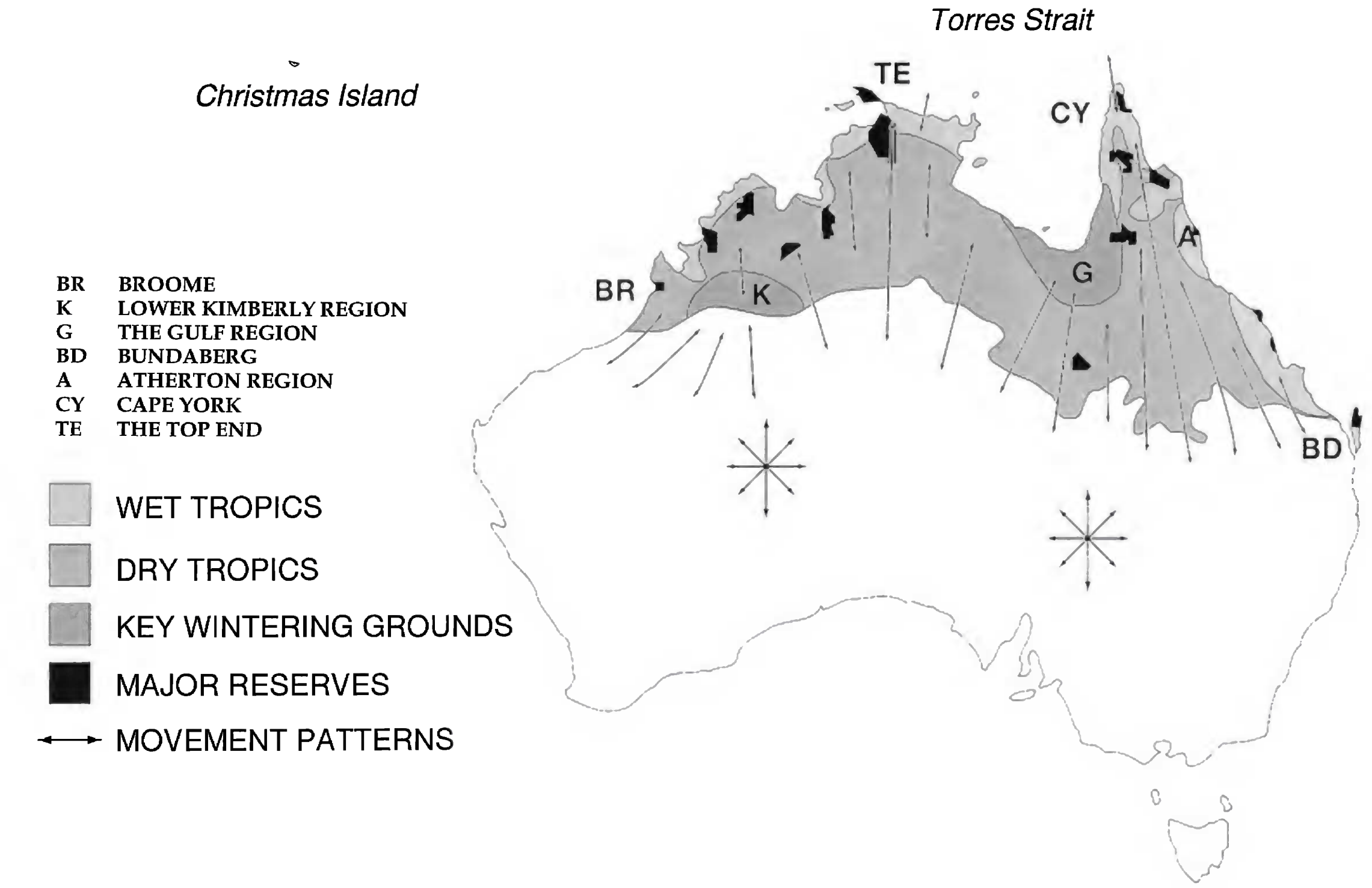

Figure 1. Key raptor wintering grounds (after Marchant and Higgins 1993), reserves, and movement patterns (after Nix 1972, Baker-Gabb and Fitzherbert 1989) in the Australian tropics.

Movements. In the Australian tropics, there are 13 resident Falconiformes, 10 regular "winter" migrants, and one species, the Black-breasted Buzzard (*Hamirostra melanosternon*), that moves to the tropics and other coastal areas in response to irregular, inland droughts. Although two regular migrants, the Black-shouldered Kite (*Elanus axillaris*) and the Black Kite are also irruptive, only the Letter-winged Kite appears to be adapted for such movements through its colonial and early breeding (Marchant and Higgins 1993). Interpreting movements for many species is difficult because their extensive ranges include populations which are resident while others are migratory on either a regular or irregular basis. This difficulty does not exist for Australia's Strigiformes. Although there are several irruptive species, the Barn Owl (*Tyto alba*), possibly the Grass Owl (*T. longimembris*), and the Southern Boobook (*Ninox novaeseelandiae*) on Tasmania seem to be at least partially migratory (Schodde and Mason 1980, Blakers et al. 1984, Hollands 1991).

After becoming concentrated in the best breeding habitats in spring, populations of some species barely leave inland breeding areas in the heat of summer (e.g., Wedge-tailed Eagles [*Aquila audax*] and Black Falcons [*F. subniger*]; Marchant and Higgins 1993). Other species such as Black Kites and Brown Falcons (*F. berigora*) make partial migrations forming concentrations in spring to undertake northward and coastward through summer and autumn. Other species like the Nankeen Kestrel and Spotted Harrier (*Circus assimilis*) disperse in early winter and rapidly return to breeding areas through late winter. The Pacific Baza (*Aviceda subcristata*) migrates altitudinally, making it inland and coastal at the same time. This is best seen in the north-south migration of the Swamp Harrier where virtually the entire breeding population is in the far southeast (mostly in Tasmania) while nonbreeding immatures are concentrated in grassy woodlands to the north.

Habitats and Areas of Raptor Concentration. A higher proportion of Strigiformes (9 of 17 species) than Falconiformes (7 of 28 species) rely on tropical closed forests. Conversely, woodlands support a higher proportion of Falconiformes (13 of 28 species) than Strigiformes (6 of 7 species).

During the dry season and during droughts, tropical woodlands become particularly important for both residents and wintering migrants. Inland grassy, woodland areas of the Kimberleys and the lower (coastward) catchments of the larger rivers around the Gulf Region are particularly important since they support the greatest raptor diversity and share the greatest abundance (Fig. 1). Grassy woodlands support mainly Brown Falcons, Swamp Harriers, Spotted Harriers, Black Kites, and Black-shouldered Kites while open forests along permanent waterways support Red Goshawks, Australian Hobbies (*F. longipennis*), Peregrine Falcons (*F. peregrinus*), and Grey Falcons (*F. hypoleucos*). Open forests throughout the area support many Brown Goshawks (*Accipiter fasciatus*) and Collared Sparrowhawks (*Accipiter cirrocephalus*). During this autumn/winter dry period, White-bellied Sea Eagles (*Haliaeetus leucogaster*) and Ospreys (*Pandion haliaetus*) sometimes travel far inland up permanent rivers (Blakers et al. 1984, Marchant and Higgins 1993) and Brahminy Kites (*Haliastur indus*) disperse into the Torres Strait (Draffon et al. 1983).

Other areas of the tropics are important as wintering grounds. For example, the developed grasslands of the Darling Downs area in southeastern Queensland support high densities of wintering Nankeen Kestrels (Baker-Gabb 1996) and any areas of open forest where small passerines are common are used by Square-tailed Kites (Debus and Czechura 1988b).

Except for a few large areas of rainforest along the north coast, most of Australia's tropical forests and woodlands are fragmented, with indistinct borders caused by combinations of soil fertility and fire regimes (Flannery 1994). Consequently, in most of the Australian tropics, raptors normally associated with closed forests such as Rufous Owls (*N. rufa*) and Grey Goshawks (*Accipiter novaehollandiae*), may range far along rivers and between wetlands using riparian forests.

STATUS

Australia's small tropical islands have disproportionate numbers of threatened (Rare, Vulnerable, or Endangered, after Garnett 1992) or insufficiently known species. The only extinct Australian raptor, the Lord Howe Island Boobook (*N. n. albana*), was endemic to an island as are five of Australia's seven Endangered or Vulnerable raptors. The highest proportion of Australia's threatened or insufficiently known raptors are those that rely on forests, particularly tropical forests (four of five Falconiformes and six of seven Strigiformes). Australia's tropical woodlands contain most threatened Falconiformes (three of four species) and closed,

wet tropical forests contain most threatened Strigiformes (four of seven species).

Nearly all of Australia's threatened and insufficiently known raptors are endemic to or have their core ranges in the tropics (three of five Falconiformes and five of seven Strigiformes; Baker-Gabb 1994). Three species of Strigiformes are classified as insufficiently known most likely because they are difficult to survey (Clark and Mikkola 1989, Garnett 1992). In reality, many species of raptors regarded as secure need further surveys and actually should be classified as insufficiently known.

Of Australia's four threatened, endemic and monotypic species, only one, the tropical Red Goshawk, is Vulnerable (IUCN 1994). The other two, the largely tropical Square-tailed Kite and the semiarid Grey Falcon, are both Rare. All three of the species have naturally low population densities (Garnett 1992, Marchant and Higgins 1993). For example, the current Red Goshawk population consists of about 350 pairs as compared to its historic population of about 440 pairs spread over nearly 1 million ha. Its population decline has been more the result of a range contraction rather than density reduction (Aumann and Baker-Gabb 1991b, Debus 1993).

Conversely, the Vulnerable Brown Goshawk (*Accipiter f. natalis*) and Moluccan Hawk-owl (*N. squampila natalis*), both endemic to Christmas Island, have high population densities but very limited distributions. There are currently an estimated 50–100 pairs of goshawks and about 600 pairs of owls on the 13 650 ha island (Hill 1996). The goshawk's naturally small and very tame population is Vulnerable in every sense but the owl has the advantage of nocturnal seclusion. There is some question as to the identity of the owl and whether the goshawk is simply a subspecies of the Grey Goshawk (Debus 1994a). These taxonomic questions must be settled in which case more attention may need to be given to the security of these isolated raptors.

THREATS AND CONSERVATION

Precaution and Prevention. Threats to Australia's tropical raptors are similar to those which threaten raptors in other countries (e.g., Thiollay 1994). However, Australia has a great advantage in that much of the management necessary to preserve these species is preventative.

Loss of Habitat—Agriculture. Both productivity and survival can be affected by loss of critical habitat (Newton 1979). In the Australian tropics, this loss has been mostly due to agriculture. Draining of wetlands is an important issue. The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention, Davis 1994) lists several large Australian tropical wetlands for conservation but most are unprotected. However, wetlands have been successfully restored by deliberate management (e.g., Anonymous 1994) and changing public attitudes may give more such opportunities. Like many species, tropical raptors are heavily reliant on remnant wetlands during the dry season or droughts. Accelerated destruction is potentially harmful both to common species, such as the White-bellied Sea-eagle, Brahminy Kite, Whistling Kite (*Haliastur sphenurus*) and Barking Owl (*N. connivens*), and to already Vulnerable species, such as the Red Goshawk.

Perhaps more than any other habitat, Australia's woodlands have suffered enormously since European colonization. In temperate areas, 80% has been cleared (Robinson and Traill 1996) and rapid inroads are being made into tropical woodlands for agriculture, especially in southern Queensland (Anonymous 1996). Square-tailed Kites, Red Goshawks and Pacific Bazas are the species most at risk from this deforestation.

Dry tropical regions are also disappearing due to the development of irrigation in desert areas. This practice has the potential to increase saltation and change flooding regimes with widespread effects on many thousands of km^2. Extensive monoculture crops are susceptible to pests requiring the use of pesticides (insecticides and rodenticides) which may have consequences for raptors. However, Australia's National Landcare Program (McLennan 1996) is slowing this and other large-scale land degradation problems such as saltation and erosion.

Loss of Habitat—Forestry. Forestry has had limited effects on Australia's tropics but the increasing demand for woodchips from native hardwood forests may change this. Plantations of exotic pines make areas unsuitable for most raptors (*accipiters* occasionally use them; Marchant and Higgins 1993) and, even if the original forest is retained, often the structure and age is so altered that raptors can no longer rely on them. This is a problem particularly for large owls needing large tree hollows such as the Rufous Owl (*N. rufa*), Powerful

Owl (*N. strenua*) and Sooty Owl (*T. tenebricosa*) (Debus 1994b).

Codes of Practice have been established for most Australian forest operations (Anonymous 1993) and contain protocols and recommendations based on specific research (e.g., Mooney and Holdsworth 1991, Brereton and Mooney 1994). In Tasmania, for example, state codes regulating every operation selling timber has been effective in conserving nesting Wedge-tailed Eagles (Mooney and Taylor 1996). Survey techniques must be improved to make pre-logging planning effective (Kavanaugh and Peake 1993, Mooney 1996).

Loss of Habitat—Urbanization. The penchant of Australians to live on coastal and subcoastal residential blocks is a further local threat to raptors. This type of land use is becoming increasingly destructive to tropical habitats in Queensland and New South Wales and brings with it all the hazards of people beyond the initial alteration of habitats (e.g., pets, persecution, egg collecting, overhead wires, vehicles, and fuel reduction burns). These rural-residential developments are particularly problematic for large owls and aggressive raptors, the latter which occasionally attack stock. Such urbanization should be more conservatively planned and education programs aimed at reducing people's expectations of what they can do in these environments should be undertaken (Wood 1996). Living With Wildlife Programs (Anonymous 1988, Temby 1992) should be more aggressively promoted by wildlife authorities.

Loss of Habitat—Other Development. The clearing of mangroves and reclamation of coastal wetlands for aquaculture, marinas, and urban areas are growing problems, most likely to affect Brahminy Kites and White-bellied Sea-eagles. Ospreys in Australia, as elsewhere, seem remarkably tolerant of humans and have adapted to many artificial nesting sites (Marchant and Higgins 1993, Ewins 1996). Mining is potentially a problem for raptors through its resulting habitat loss and pollution. For example, 25% of Christmas Island was badly degraded from mining (Hill 1996) and a large uranium mine (Ranger Mine) exists in Kakadu National Park, Australia's premier tropical reserve.

Loss of Habitat—Fire. Fire is more a qualitative problem than other more recent threats to habitat; closed forest is turned to open forest, open forest is turned to woodlands and woodland to grassland. Fire is a fundamental ecological shaper in Australia's tropics (Flannery 1994). Although some species directly benefit from it, such as Black Kites, Whistling Kites, and Brown Falcons that forage in front of fires (Marchant and Higgins 1993), fire occasionally kills nestling raptors (Aumann and Baker-Gabb 1991a). However, more serious is fire's attritive affects on remnants of closed forest that are so important to raptors such as the Rufous Owl. Not only can traditional nest trees be burned and nest stands reduced in size but they can also be degraded by weeds and introduced predators (Baker-Gabb 1994). Fire is a traditional and necessary land management tool in much of Australia (Flannery 1994) but it is not always the right tool.

Disturbance. Disturbance can have severe effects on raptor productivity. Tourism is now one of the most important industries in the Australian tropics and amongst raptors its disturbing effects are most felt by breeding White-bellied Sea-eagles on large wetlands and coastal rivers which are favorite tour stops. The ground-nesting Grass Owl may be at special risk from tourism (Gamauf 1994). National park authorities need to consider temporary zoning restrictions and tour operators should develop other tours that do not come into close proximity with nesting owls. There is a great deal of opportunity for innovation in such ecotourism. Inexperienced photographers can also cause nesting failures, possibly effecting marginal populations (Garnett 1992).

Loss of Prey. The rapid spread of rabbit calicivirus disease is expected to decimate populations of rabbits in Australia (Coman 1996). Rabbits do occur in the dry tropics (Williams et al. 1995) but in far lower densities than in more southern regions. Hence, they are far less important in the diets of tropical raptors. Species most likely to be affected are Wedge-tailed Eagles and Little Eagles (*Hieraaetus morphnoides*), but the effects will probably be small and restricted to locally diminished productivity. The effect of this disease on raptor populations is being monitored both locally and nationwide using a road transect survey called Bird of Prey Watch (Baker-Gabb 1996). In the long term, the removal of rabbits should allow vegetation to recover in large areas increasing its value for wildlife (Mutze 1996). However, there are private plans to increase livestock grazing (the density of sheep and cattle) in these areas immediately after the rabbits are eradicated, perhaps negating some of the benefits for wildlife. Agricultural authorities should consider stocking restrictions to balance these pressures. Black-breasted Buzzards,

Black Falcons, Grey Falcons, and Letter-winged Kites are the most susceptible to grazing pressures.

Collecting. Egg collecting is a small but persistent problem targeting uncommon species. Once nests of species such as Red Goshawks or Grey Falcons become well known they may be robbed (Cupper and Cupper 1981, Hollands 1984, Garnett 1992, Baker-Gabb 1993, Marchant and Higgins 1993) and it is the responsibility of researchers and photographers to restrict this knowledge. At worst, it is a local problem for a few species. Recreational falconry is not allowed in Australia and there is little consequent nest robbing and no pet trade.

Persecution. Australia is a member of CITES and all raptors in Australia have full legal protection under state and territory laws (Aumann et al. 1989). However, wildlife authorities retain the right to issue special permits to control raptors. Persecution of raptors in the Australian tropics is only a local problem. Beyond random vandalism the biggest problems are associated with the defense of stock. Accipiters are commonly shot near poultry and aviary birds; the Brown Goshawk was heavily persecuted on Christmas Island (Van Tets 1967) but this now has diminished. Wedge-tailed Eagles are still reported to cause losses of lambs and even calves (Keough 1994), and are frequently shot, trapped, or poisoned. Such shooting is still common in western Queensland and several stockmen shoot eagles from helicopters (Czechura, pers. comm.). Persecution may be an important contributing factor to the range contraction of the Red Goshawk from northern New South Wales and most of southeastern Queensland (Debus and Czechura 1988a, Baker-Gabb 1993). Besides policing, education (especially use of peer pressure) is one of the few ways to limit such persecution. Present efforts (Holdsworth and Marmion 1993) should be consolidated and expanded. Australia's new, strict, national gun laws can only help reduce persecution of raptors.

Pesticides. Pesticides can affect both productivity and survival of raptors. The effects of some persistent organochlorine pesticides such as DDT and dieldrin are reasonably well known (Riseborough 1987) but today they are probably of little consequence for populations of Australian raptors (Fuller and Maples 1993). The increasing problem of malaria in the nearby Solomon Islands brings greatly increased use of DDT and if climates change, the possibility of malaria establishing in Australia exists.

The effect of most pesticides, especially when used as cocktails, is little known and perhaps presents new dangers for Australian raptors. This especially applies to cotton crops on which large amounts of pesticides are traditionally used.

Some pesticides (rodenticides and insecticides) are highly toxic and raptors have been killed by them in Australia. Experiences in Israel have shown how catastrophic the use of topical, organophosphate rodenticides or insecticides can be for raptors (Mendelssohn and Puz 1977). A recent accidental kill of up to 20 000 Swainson's Hawks (*Buteo swainsoni*) by the organophosphate insecticide monocrotophos on their Argentine wintering grounds (Krapovickas and Lyons 1997) shows the potential of organophosphate insecticides to seriously affect populations of Nankeen Kestrels, Brown Falcons, Little Eagles, Masked Owls (*T. novaehollandiae*), Barn Owls, Grass Owls, Whistling Kites, Black Kites, Black-shouldered Kites, and Letter-winged Kites in Australia. The use of pesticides should be under severe restrictions in areas where these species are likely to winter or concentrate to breed. Even in established agricultural areas, large concentrations of wintering raptors can be found (e.g., Nankeen Kestrels on the Darling Downs), benefiting from limited agriculture, but the use of highly-toxic chemicals must be controlled in these places. Agricultural Codes of Practice along the lines of Forestry Codes of Practice could have obvious use.

Dingo/feral dog (*Canis familiaris*) and feral pig (*Sus scrofa*) poisoning programs use sodium monoflouroacetate (1080), a chemical to which Australian raptors are somewhat resistant (McIlroy 1984, 1986). Nevertheless, illegal baiting using organophosphates (lucijet, a fenthion-ethyl derivative, and phosdrin) can and does kill raptors (DuGuesclin et al. 1983).

Exotic Species. Besides the risks of nontarget poisoning, introduced species present many problems to raptors. The cane toad (*Bufo marinaris*) is highly toxic and it may have killed raptors after its release. Today, it is a common prey item of the Black Kite (Marchant and Higgins 1993). Foxes (*Vulpes vulpes*) and feral cats (*Felis domesticus*) can compete with and prey on raptors and both are found in the dry and wet tropics. Their potential effect is greatest for ground nesters such as the Grass Owl and small, colonial nesters such as the Letter-winged Kite (Cupper and Cupper 1981). Such depredation may increase because of prey

switching when rabbit calicivirus disease decimates rabbits.

Beyond plantation forestry or agriculture, introduced plants can change large areas. Afro-Asian prickly acacia (*Acacia nilotica*) has changed nearly 50 000 km^2 of grassland in Queensland to tall scrub (Anonymous 1990). Much of this was potentially valuable wintering habitat for raptors.

Under the federal Endangered Species Protection Act 1992, research and management phases of Recovery Programs for species threatened nationally are funded by the Australian Nature Conservation Agency. Funding to carry out follow-up recommnedations is not guaranteed. Fortunately, there is no remedial action urgently needed for any threatened species except perhaps for the Red Goshawk in New South Wales and southeast Queensland (Auman and Baker-Gabb 1991b).

Reserved Status. A common conservation measure for wildlife is to protect land through the establishment of reserves. For this to be effective, the most important areas of habitat must first be identified. Some rare species, such as the Square-tailed Kite, have an enormous distribution, are migratory through dispersive rather than routed mechanisms, and seem always at low population densities making accurate assessment of their status and identification of crucial wintering areas very difficult. The large home ranges of many breeding raptors necessitates enormous reserves to support viable populations (Thiollay 1989). About 5.9% of Australia is under reservation for conservation, compared to 10.5% for the U.S., 7% for Canada and a world average of 4.9% (McLennan 1996). Although Australia's proportion seems small, protected areas in the north are well connected by relatively intact habitat. Most of the islands, Christmas Island included, are now well reserved. Although all Australian raptors are found in at least one reserve, Australia has no large reserves dedicated to raptors similar to those found in Israel, Spain, and the U.S. This is due to the fact that Australia's reserves are generally for the conservation of mammals, a group in far more need of special attention than raptors (Flannery 1994).

CONCLUSION

The vast majority of tropical Australia is still sparsely populated by people and environmental degredation is at a low level. As a result, problems for raptors in Australia's tropics are generally localized but development has resulted in significant contraction of range for at least one species, the Red Goshawk. Fortunately, no raptor in Australia is in need of intensive management. Beyond making deliberate efforts to preserve a few subspecific island populations, further researching insufficiently known and rare species, and confirming the security of most species through regular monitoring of populations and threats, aggressive education and development of Codes of Practice are probably all Australia's raptors need for security well into the 21st century.

ACKNOWLEDGMENTS

I would like to thank Henry Nix, Richard Hill, Penny Olsen, and Stephen Debus for their thoughts on raptors in Australia's tropics. Will Steele, Dave Baker-Gabb, and Richard Hill kindly let me use their unpublished data Dave Baker-Gabb and Jean-Marc Thiollay kindly reviewed the text and the Raptor Research Foundation helped me attend the conference in Boise where this paper was presented.

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Received 16 October 1996; accepted 15 October 1997